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SUBJECT: **ARCHITECTURAL TECHNICAL GUIDE 0002 (January 1, 2005)**
Professional Foundation and Concrete Slab-on-Grade Design and Certification: Requirements for Single Family Housing New Construction and Additions

PURPOSE:

The purpose of this Architectural Technical Guide (ATG) is to discuss Rural Development's long running practice in Colorado of requiring that a professionally certified foundation system and concrete slab-on-grade system design be provided for all new residences (as well as new additions to existing residences) financed under the authorities of the Section 502 Direct and Guarantee Loan Programs. This special certification requirement is in addition to the more general "final drawings and specifications" certification required by Subparagraph 1924.5(f)(1)(iii) of Rural Development Instruction 1924-A. This special certification should be accomplished by either a Colorado registered architect or engineer.

Historical experience has shown that a variety of hazards posed by very unpredictable subsurface conditions across Colorado have often resulted in excessive foundation and concrete slab-on-grade remedial costs to borrowers and the U.S. government. The requirements of this ATG are intended to help mitigate such incidents by calling for site-specific geotechnical investigation resulting in compatible foundation system and concrete slab-on-grade system designs.

IMPLEMENTATION RESPONSIBILITIES:

All foundation systems and concrete slab-on-grade systems intended to be installed for newly constructed residences and additions to existing residences financed under the Section 502 Rural Housing Program should be designed and certified by either a Colorado registered architect or engineer. This should become a loan making condition and should be determined a reimbursable expense, incurred by the general contractor as part of the total development cost. The general contractor should arrange for and itemize a maximum bid price for all necessary professional services related to:

(1) Direct Loan Program:

(a) Producing three complete sets of registered architect or engineer sealed construction drawings and specifications (for the applicant, contractor, and Rural Development), pertaining only to the foundation system as well as the interior and exterior concrete slab-on-grade systems for the new residence or addition;

(b) Completing a related certification (*"Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification"*, Exhibit A, to this ATG), also pertaining only to the foundation system and concrete slab-on-grade systems for the new residence or addition;

(c) Performing any additional investigative work determined necessary by the design architect or engineer to verify actual subgrade conditions; and

(d) Accomplishing any redesign work necessitated by verified subgrade conditions actually encountered.

(2) Guaranteed Loan Program:

(a) Producing two complete sets of registered architect or engineer sealed construction drawings and specifications (for the applicant and contractor), pertaining only to the foundation system and concrete slab-on-grade systems for the new residence or addition;

(b) Completing a related certification (*"Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification"*, Exhibit A, to this ATG), also pertaining only to the foundation system and concrete slab-on-grade systems for the new residence or addition;

(c) Performing any additional investigative work determined necessary by the design architect or engineer to verify actual subgrade conditions; and

(d) Accomplishing any redesign work necessitated by verified subgrade conditions actually encountered.

Prior to the obligation of Section 502 funds under the Direct Loan Program, the Rural Development loan manager should review and accept three identical and complete sets of foundation system construction drawings, specifications, and the Exhibit A certification. Particular attention should be focused on whether or not the foundation system and concrete slab-on-grade systems drawings and specifications address special concerns as identified in items 1 through 8 of the *" Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification"* (i.e. concerns regarding whether or not a foundation subdrainage system or replacement of existing subsoils under to-be-poured concrete slabs would be necessary). If these drawings and specifications appear inadequate in this regard, they should not be accepted without appropriate revision work.

Prior to the obligation of Section 502 funds under the Guarantee Loan Program, the Rural Development loan manager should insure the lender has provided adequate evidence that the above discussed foundation system and concrete slab-on-grade system(s) design and certification have been properly accomplished. This would constitute the final Rural Development oversight role in this regard with the exception of future site follow-up observations (discussed further below) and the foundation wall height verification requirements (discussed in **ARCHITECTURAL TECHNICAL GUIDE 0018** Foundation Height Certification: Requirements for Single Family Housing New and Existing Construction).

Please note that the Rural Development accepted sets of foundation system and concrete slab-on-grade system construction drawings, specifications, and the Exhibit A certification (all prepared by the Colorado registered architect or engineer) would be intended to become part of the complete construction contract documents to be contractually used between the homeowner and the home builder. The construction contract documents would otherwise be comprised of the regular set of construction drawings and specifications [i.e. completed *"Description of Materials"* form] prepared by the home designer [i.e. architect or architectural plan service]). The foundation system and concrete slab-on-grade system construction drawings, specifications, and the Exhibit A certification would be intended to take precedence over the regular set of construction drawings and specifications in any areas of the construction work where technical conflicts might occur between the two series of exhibits. The regular construction drawings and specifications, for example, might require the installation of a pair of horizontal #4 reinforcing steel bars be placed in the footing while the foundation system construction drawings, specifications, and the Exhibit A certification might require the installation of a pair of horizontal #5 reinforcing steel bars instead. The foundation system and concrete slab-on-grade system construction drawings, specifications, and the Exhibit A certification, intended to be based on the regular set of construction drawings and specifications, would also be intended to adapt the regular design to the site specific geotechnical constraints evaluated by the professional foundation designer and take precedence. The preparer of the regular set of construction drawings and specifications and the preparer of the foundation system and concrete slab-on-grade construction drawings, specifications, and the Exhibit A certification could be the same party provided the preparer held the proper professional credentials (Colorado registered architect or engineer) and prepared the necessary foundation system and concrete slab-on-grade system design and certification documents required by this ATG.

Prior to the issuance of payment to the Contractor for any foundation system work-in-place under the Direct Loan Program, the Rural Development loan manager should inspect (as time constraints apply) the following portions of the work to determine general consistency with the Rural Development accepted foundation drawings and specifications. Rural Development loan managers are urged to coordinate site visits to inspect as many items as possible during a single trip. Form RD 1924-12, *"Inspection Report"*, should be completed for each trip and should document pertinent field observations regarding the following foundation system and concrete slab-on-grade system aspects:

(1) **Subgrades:** Prior to the placement of any permanent foundation system and/or concrete slab-on-grade system components, actual subgrades should be studied to ascertain consistency with the soil type(s) and subdrainage features upon which the foundation design was originally based, as stated in the completed Exhibit A, *" Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification "*. If an unanticipated high water table were encountered during actual construction, for example, a previously accepted basement design might need to be reconsidered for changeover to a crawlspace or slab-on-grade design without a basement. Any significant inconsistencies should be immediately brought to the attention of the home builder and the borrower, as well as to the professional foundation system and concrete slab-on-grade system designer, as warranted.

(2) **Forms and Reinforcing Steel:** Prior to concrete pouring, forms and reinforcing steel placement should be evaluated for: correct form size (i.e. correct wall thickness, height, and length), forming system type (see further discussion below) correct reinforcing steel bar quantity (as specified), correct bar diameter and length (as specified), proper reinforcing steel bar type (deformed rib bar vs. smooth bar), proper reinforcing steel bar location (as specified), reinforcing steel bar cleanliness (no mud or oil presence on the bars), unacceptable rusting (excessive), proper reinforcing steel bar tying (to resist movement while pouring concrete), and minimum concrete cover for reinforcing steel bars (thickness between steel and soil

or air: see table below). Any noteworthy inconsistencies should be brought to the attention of the home builder and the borrower. Reinforcing steel bars are number in eighths of an inch in diameter. A #4 bar, for example, would be a 4/8-inch =1/2-inch diameter bar. Most reinforcing bars encountered would be the deformed rib type, intended to resist movement against adjacent concrete inside concrete pours. Smooth reinforcing bars would be appropriate at slip joint situations, where poured concrete would be intended to move against the bar within the same plane.

Minimum Concrete Cover for Reinforcing Steel in Cast-in-Place Concrete

Concrete cast against the soil:	3 inches
Concrete exposed to weather:	2 inches
Concrete not exposed to soil or weather:	3/4-inch

Insulated concrete forming (ICF) systems are starting to be seen more and more in Rural Development funded SFH construction. They are basically a substitute for the traditional wood or steel forming systems for cast-in-place concrete; are left in place permanently; and provide permanent foundation insulation in place on both sides of the foundation stem walls (they are typically placed on top of poured concrete footings). These ICF systems have gone through the HUD and model building code review and approval processes and are being marketed in all states. Each propriety system is slightly different in design and assembly. They may be used for Rural Development SFH construction as a substitute for the traditional manner for providing concrete forming and permanent foundation insulation provided they are installed in strict accordance with the engineered foundation system design and the manufacturer's written instructions. They are not a substitute for the structural concrete they encase, however, and should form the thickness and height of concrete required by the engineered foundation system design. Reference Exhibit C to this ATG for more discussion on ICFs.

(3) **Concrete Placement:** During and after concrete pouring, the following concrete placement aspects should be scrutinized: state of completion; aggregate content in concrete mix (a variety of aggregate sizes should be used); undesirable water addition to the concrete mix (water added to a concrete ready mix, to improve the workability of the mix after pouring, reduces ultimate concrete compressive strength); serious cracking after concrete placement (usually due to either a pour concrete mix, shrinkage cracking, or problems with the underlying fill materials); excessive fall of concrete during placement (exceeding 3 feet vertically); quality and correctness of horizontal surface finishing (smooth or broomed finish: a broomed finish is preferred for exterior concrete flatwork while a smooth finish is preferred for interior concrete pours); unpatched "honeycombing" (honeycombs are areas of a concrete surface where either voids have occurred or pulled forms have removed some concrete material); unacceptable cold weather placement (allowed to freeze or placed at temperatures below 40 degrees F without special measures taken); and evidence of proper curing methods (flooded with water, an acceptable curing membrane installed, or an acceptable curing compound sprayed on the surface).

If possible, a spot check of receipts for ready mixed concrete shipments delivered to the site should also be performed to verify the 28-day compressive strength of the shipments at least equals that originally specified. Concrete reaches nearly 100 percent of its compressive strength 28 days after it has been poured. Typically the following minimum 28-day compressive strengths should be specified (as modified by the more stringent requirements of the home and foundation designer(s), where present):

Recommended Cast-in-Place Concrete 28-day Minimum Compressive Strength

Footings:	2,500 p.s.i.
Foundation stem walls:	3,000 p.s.i.
Concrete flatwork exposed to weather:	3,500 p.s.i.
All other concrete flatwork:	3,000 p.s.i.

Any significant inconsistencies should be brought to the attention of the contractor and the borrower.

(4) **Peripheral drain:** Prior to backfilling, peripheral subdrainage systems (if required in the certified design) should be analyzed for: correctness of materials (as specified), overall workmanship, proper slope to the outfall point (as specified or minimum 1/8" fall per linear foot, whichever is more stringent), proper highest elevation point (the top of the highest point of the system should be below the bottom-of-footing level, outside the 45-degree structural loading line), and proper outfall (drain to daylight or to a storm sewer connection: outfall to a sump pump would be the last resort). Any noteworthy inconsistencies should be brought to the attention of the contractor and the borrower.

(5) **Dampproofing:** Prior to backfilling, dampproofing should be inspected for: proper type (as specified), proper temperature placement (per manufacturer's instructions), complete coverage, (all areas below grade), and continuity (unbroken surface).

Any significant inconsistencies should be brought to the attention of the contractor and the borrower.

(6) **Special Considerations for Concrete Slabs-on-Grade:** Concrete slabs-on-grade are standardly reinforced with either 6”x6” (grid), 10/10 gauge, welded wire mesh, reinforcing steel or fibermesh reinforcing fibers (the latter is added directly to the concrete mix) to control temperature induced cracking during the concrete curing period. If not provided, widespread hairline surface cracking can more easily result.

Interior located concrete slabs-on-grade, where floor finishes would be applied (i.e. sheet vinyl flooring or carpeting), should be immediately underlain with a minimum 6-mil thick, polyethylene, vapor barrier (lapped minimum 6 inches at seams) placed on a minimum 2-inch thick layer of clean sand or pea gravel, to retard the rate of release of moisture from underlying subsoils into the concrete.

Interior concrete slabs-on-grade should normally receive a smooth finish and exterior concrete slabs on grade should normally receive a broom finish.

All concrete slabs-on-grade should normally receive concrete control joint placement (usually a ¼-inch deep saw-cut or otherwise neatly tooled seam at the surface) at maximum 20 feet in any direction and for a maximum area of 200 square feet between control joints.

All concrete slabs-on-grade should be "floating slabs", separated from all foundation walls, column bearing pads, and slab penetrations (i.e. utility lines) by expansion joints and other approved sleeves, to allow for future movement without cracking.

All exterior and garage concrete slabs-on-grade should be placed on subsoils prepared in the manner required by the foundation system and concrete slab-on-grade system construction drawings, specifications, and the Exhibit A certification design architect or engineer.

All concrete slabs-on-grade should have a vapor retardant applied to their finished surfaces to control the rate of concrete surface curing.

All exterior slabs-on-grade should slope away from foundation walls. Reference more discussion on exterior finish gradients in **ARCHITECTURAL TECHNICAL GUIDE 0013** Special Site Grading Design Criteria for Surface Storm Water Drainage and to Accommodate Persons with Disabilities: Requirements for Single Family Housing New and Existing Construction, Exhibit A.

Additional structural reinforcing steel may need to be placed in some concrete slabs-on-grade to address special problems related to poor subsoils. Please reference discussions provided in the attached exhibit, "*Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification*", to be completed by the foundation system and concrete slab-on-grade system construction drawings, specifications, and the Exhibit A certification design architect or engineer.

Additional inspection guidance is provided in, *"Stage 1 Inspection Checklist: Foundation Systems and Concrete Slab-on-Grade Systems"*, Exhibit B to this ATG. The contents of this guide are intended to facilitate performing the Stage 1 inspection.

Events in the construction arena do not always proceed as planned, even with the best of intentions. The State Architect should be consulted for evaluation and recommendations regarding noncompliances, corrections, alternatives, conflicts, etc. In most cases, an acceptable mitigative solution can probably be found. Cost is usually the bottom line.

All requirements of this Architectural Technical Guide should be fully explained to applicants, contractors, and lenders prior to obligating funds.

DAVID W. RIGIROZZI
State Architect
USDA/Rural Development

Attachments: Exhibit A, *" Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification "*
Exhibit B, *"Stage 1 Inspection Checklist: Foundation Systems and Concrete Slab-on-Grade Systems"*
Exhibit C, *"Insulated Concrete Forming (ICF) Systems"*

Foundation System and Concrete Slab-on-Grade System Architect's/Engineer's Design and Certification

(The following statement shall be attached to the professional architect or engineer stamped foundation drawings for the U.S. Department of Agriculture/Rural Housing Service (USDA/RHS) assisted residence in question.)

Concerning the proposed residence to be located at ____, these foundation system and concrete slab-on-grade system drawings and specifications, dated_______________________), have been prepared from the results of a thorough investigation of site specific soils which have been determined to exhibit the following characteristics:

1. Dominant soil geological series name: ____.
2. Design soil bearing pressure (p.s.i.): ____.
3. Design frost depth (inches): ____.
4. Approximate depth to high water table: ____.
5. Sulfate resistant concrete necessary: _____yes _____no.
6. Foundation subdrainage system necessary: _____yes _____no.
7. Special subsoils over-excavation/replacement necessary: _____yes _____no.
8. Should lawn irrigation be practiced within 5 feet of the foundation? _____yes _____no.
9. Dominant ASTM Unified Soil Classification System soils group(s) (check, as applicable):

	FOUNDATION BEARING LEVEL:		SLAB BEARING LEVEL:
___GW	Well-graded gravels, gravel-sand mixtures mixtures little or no fines.	___GW	Well-graded gravels, gravel-sand little or no fines.
___GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.	___GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
___SW	Well-graded sands, gravelly sands, little or no fines.	___SW	Well-graded sands, gravelly sands, little or no fines.
___SP	Poorly graded sands or gravelly sands, little or no fines.	___SP	Poorly graded sands or gravelly sands, little or no fines.
___GM	Silty gravels, gravel-sand-silt.	___GM	Silty gravels, gravel-sand-silt.
___SM	Silty sand, sand-silt mixtures.	___SM	Silty sand, sand-silt mixtures.
___GC	Clayey gravels, gravel-sand-clay mixtures.	___GC	Clayey gravels, gravel-sand-clay mixtures.
___SC	Clayey sands, sand-clay mixture.	___SC	Clayey sands, sand-clay mixture.
___ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	___ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
___CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. clays.	___CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean
___CH	Inorganic clays of high plasticity, fat clays.	___CH	Inorganic clays of high plasticity, fat clays.
___MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	___MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic soils.
___OL	Organic silts and organic silty clays of low plasticity.	___OL	Organic silts and organic silty clays of low plasticity.
___OH	Organic clays of medium to high plasticity, organic silts.	___OH	Organic clays of medium to high plasticity, organic silts.

The necessities of using special foundation system and concrete slab-on-grade system design features, including but not limited to subsoils preparation and subdrainage requirements, to meet the U.S. Department of Agriculture, Rural Housing Service's "development standard", governing state and local codes and ordinances, soil hazard alleviation, and good professional practice have been fully addressed in the attached foundation system and concrete slab-on-grade system drawings and specifications, entitled, ______________________________ ____.

SIGNED:____

COLORADO LICENSE NO.:____

FIRM NAME:____

FIRM ADDRESS:____

FIRM TELEPHONE NO.:____

DATED:____

(WARNING: Title 18 U.S.C. 101, provides in part that whoever knowingly and willfully makes or uses a document containing any false, fictitious, or fraudulent statement or entry, in any matter in the jurisdiction of any department or agency of the United States, shall be fined not more than $10,000 or imprisoned for not more than five years or both.)

Stage 1 Inspection Checklist: Foundation Systems and Concrete Slab-on-Grade Systems

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[The contents of this report are confidential and are the property of the U.S. Department of Agriculture/Rural Housing Service (USDA/RHS). Any other use or reproduction without the express authorization of USDA/RHS is strictly prohibited. If this report is included in the borrower's case file, it will not be released unless so authorized through a Freedom of Information or Privacy Act request. The applicant/borrower should not be asked to sign or review this checklist. This checklist is to be used as a guide only and should not be considered as a development standard. Appropriate observations and comments should be documented in the space before and following each item.

This report is based on a visual inspection only in easily accessible areas and; therefore, cannot and does not guarantee that defects, whether structural, mechanical, or otherwise, do not exist.]

A. **PERMITS:**

_____ Building permits secured? ____________________

_____ Well permit secured? ____________________

_____ Water tap secured? ____________________

_____ Septic/drain field permit secured? ____________________

_____ Sewer tap secured? ____________________

_____ Other: ____________________

B. **INSURANCE:**

_____ Builder's risk policy in effect for full contract price and full construction period? ____________________

_____ Workman' compensation fund policy in effect for general contractor's employees? ____________________

_____ Other: ____________________

C. **EQUAL EMPLOYMENT OPPORTUNITY AND LABOR COMPLIANCE:**

_____ Form RD 400-6, "Compliance Statement", secured for all contracts/subcontracts > $10,000? ____________________

_____ Form AD-767, "Equal Employment Opportunity Contract Compliance Notices", attached to all contracts/subcontracts > $10,000? ____________________

_____ 41 CFR 60 - 1.4 (a) & (b), "Equal Opportunity Clause", attached to all contracts/subcontracts > $10,000? ____________________

_____ U.S. Department of Labor, poster, WH Publication 1321, "Notice to All Employees", properly displayed on site for contracts/subcontracts > $10,000? ____________________

_____ U.S. Department of Agriculture, poster, Form AD-475-C, "And Justice for All", properly displayed on site for contracts/subcontracts > $10,000? ____________________

_____ Evidence of discrimination or unsafe work practices? ____________________

D. **GENERAL SITE WORK:**

_____ Site neat? ____________________

_____ Existing trees to be saved properly protected? ____________________

_____ Temporary positive drainage provided? ____________________

_____ Property lines staked? ____________________

_____ Materials for which payment is requested are properly stored within the property lines? ____________________

_____ Topsoil stripped and stockpiled? ______________________________

_____ Other: ______________________________

E. EXCAVATION WORK:

_____ Sides stabilized? ______________________________

_____ Bottom free of debris at locations for concrete pours? ______________________________

_____ Stumps located under foundation bearing points removed to minimum 12" below grade? ______________

_____ Other: ______________________________

F. BACKFILL WORK:

_____ Placed in lifts under 12" thick? ______________________________

_____ No topsoil used under foundation bearing locations? ______________________________

_____ No frozen fill material placed? ______________________________

_____ Termite treatment scheduled prior to backfilling? ______________________________

_____ Backfilling scheduled after attachment of floor framing to foundation? ______________________

_____ No cobbles exceeding 6" in dimension in backfill material? ______________________

_____ Other: ______________________________

G. UTILITIES WORK:

_____ Specified materials/sizes installed? ______________________________

_____ Water lines installed below frost depth? ______________________________

_____ Water piping not installed in or below gravel? ______________________________

_____ Sewer and storm drainage lines at minimum 1/8" per foot slope (preferably 1/4" per foot) to connection? ______________________________

_____ No joints in water lines below slabs? ______________________________

_____ Sewer lines within 6' of water lines are located minimum 12" below water lines? ______________

_____ No defective (i.e. ruptured) appearing materials used? ______________________________

_____ Only new materials used? ______________________________

_____ All piping sleeved through foundation walls and slabs? ______________________________

_____ All materials joined are dielectrically compatible (i.e. copper-to-brass-to steel)? ______________

_____ Steel lines underground coated for corrosion protection? ______________________________

_____ Other: ______________________________

H. FOOTING, PADS, FOUNDATION WALLS, AND SLABS:

_____ Forms level, straight, and true, with tight fitting joints? ______________________________

_____ Uniform form pour width? ______________________________

_____ Clean form contact surfaces? ______________________________

_____ Wood forms wetted down immediately prior to pouring? ______________________________

_____ Forms not removed prematurely? (See table on the next page)______________________________

Average Daily Temperature (degrees F)	Minimum Period of Protection (days)	
	Cement Type	
	I	II
40 to 100+	2 to 7	3 to 10
24 to 39	14	20
16 to 23	21	28
16-	29	35

_____ Dimensions per contract documents? ______________________________

_____ Correct number, size, and location of reinforcing steel? ______________________________

_____ Reinforcing steel clean, not oily, and relatively free of surface rusting? ______________________

_____ Reinforcing mesh located in middle of slabs? ______________________________

_____ Reinforcing bars correctly tied? ______________________________

_____ Reinforcing bars not bent below minimum bend diameter (6 x bar diameter)? ____________________

_____ Minimum concrete cover provided for reinforcing bars? (see table below) ____________________

Application	Minimum Concrete Cover (inches)
Concrete in contact with earth :	**3**
Concrete exposed to weather:	**2**
Concrete beams and columns:	**1-1/2**
Other applications:	**3/4**

_____ Aggregates well graded? ____________________

_____ Only potable water used in on-site mixed concrete? ____________________

_____ Water not added to plant mixed concrete for workability? ____________________

_____ Concrete placed within 45 minutes of mixing? ____________________

_____ Concrete not dropped over 3'? ____________________

_____ Concrete not allowed to freeze in first 24 hours? ____________________

_____ Concrete maintained at minimum 40 degree F for first two weeks? ____________________

_____ Slab kept moist by an approved method after completion of finishing? ____________________

_____ Proper slab finish? ____________________

_____ Excess concrete not dumped on the site? ____________________

_____ Expansion joint (1/2" felt or equivalent) installed at slab perimeter? ____________________

_____ Column and utility slab penetrations sleeved? ____________________

_____ Control joints (1/4" sawcut or equivalent.) provided to subdivide slab in max. 200 sf areas? ____________

_____ Foundation dampproofed prior to backfilling, if basement construction? ____________________

_____ Evidence of water table problems? ____________________

_____ Other: ____________________

I. ALL-WEATHER WOOD FOUNDATION SYSTEMS:

_____ Construction level, straight, and true, with tight fitting joints? ____________________

_____ Pressure-treated lumber and plywood used, as specified? ____________________

_____ Polyethylene film on exterior side of foundation wall, if galvanized nails used? ____________________

_____ Stainless steel, aluminum, copper nails used, if polyethylene film not provide? ____________________

_____ Foundation dampproofed, if polyethylene film not provided? ____________________

_____ Nailing type and spacing as specified? ____________________

_____ Lumber and plywood thicknesses as specified? ____________________

_____ Other: ____________________

J. FOUNDATION SUBDRAINAGE SYSTEMS:

_____ Sizes, types, and locations of materials as specified? ____________________

_____ Perforated pipe used against the foundation wall? ____________________

_____ Solid pipe used elsewhere? ____________________

_____ Entire system sloped to drain at minimum 1/8" per foot, or steeper, if specified? ____________________

_____ System drains by gravity either to daylight or to an underground or surface storm drainage system? ____________________

_____ Perforated pipe set in trench of gravel, as specified? ____________________

_____ Perforated collection pipe located below bottom of footing outside the 45-degree structural loading line? ____________________

_____ Gravel trench wrapped in filter fabric, if specified? ____________________

_____ Other: ____________________

SIGNED: ____________________

TITLE: ____________________

DATE: ____________________

Insulated Concrete Forming (ICF) Systems

Insulating concrete forms (ICFs) are rigid plastic foam forms that are filled with reinforced concrete to create structural walls. They hold concrete in place during curing and remain in place afterwards to provide thermal insulation. ICFs are used to make structural concrete walls, and can be used to make either foundation or above-grade walls. The forms are typically made from pure foam-plastic insulation but may also be made from a composite of cement and foam insulation or a composite of cement and processed wood. The foam is typically either expanded polystyrene (EPS) or extruded polystyrene (XPS) and occasionally polyurethane.

Form Types

Insulated Form types break down into three categories:

> ***Panel*** systems are the largest units, available in sizes from approximately 1'-3" x 8'-9" up to 4' x 12' resembling traditional plywood forms in size and shape. Panel systems allow a large section of wall area to be erected in one step, but may require more cutting in the field. The panels have flat sides and are connected to one another with metal or plastic ties. They can be shipped flat.
>
> ***Plank*** systems consist of long, narrow planks of foam held together at a constant distance apart by metal or plastic ties. Planks may have notched, cut, or drilled edges that the ties fit into. Plank-shaped forms range in height from 8 to 12 inches and are either 4 or 8 feet long. Plank systems differ from block systems in that they can be shipped flat, either because the ties can bend or because the ties are inserted as the wall is constructed.
>
> ***Block*** systems resemble hollowed-out concrete masonry units (CMU) in size and shape, although the dimensions may vary from the typical CMU. Block systems include units ranging from standard concrete block size (8-inches high x 16-inches long) to a much larger 16-inches high x 48-inches long. Their edges interlock without separate fasteners, using a rabbeted edge, tongue-and-groove configuration, mortise and tenon-type configuration, or similar. Blocks arrive on-site, ready to stack with their ties, made of the form material itself, metal, or plastic imbedded in the form.

Form Shapes

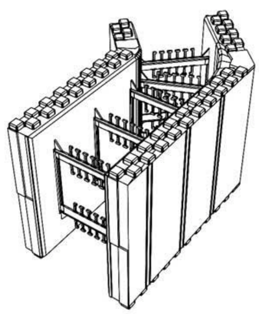
ICFs are further differentiated based on the shape of the concrete once poured into the forms. Four distinct cavity shapes are possible: flat, waffle-grid, screen-grid, and post and beam.

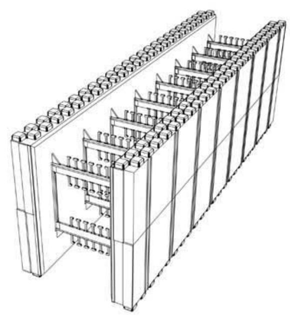
> ***Flat ICF Wall Systems*** have a solid concrete wall of constant thickness, just like a conventional poured wall formed with plywood or metal forms. They typically have a nominal concrete thickness of 4, 6, 8, 10 or 12 inches (actual thickness of the concrete can range ½ inch plus or minus the nominal thickness).

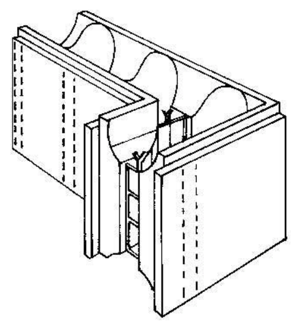
Waffle-Grid ICF Wall Systems have a solid concrete wall of varying thickness and, as the name implies, look like a breakfast waffle. These systems have a nominal concrete thickness of 6 or 8 inches for horizontal and vertical concrete cores. Maximum spacing of vertical cores is typically 12 inches on center and maximum spacing of horizontal cores is typically 16 inches on center. The webs in between the cores usually have a minimum thickness of 2 inches.

Screen-Grid ICF Wall Systems have a perforated concrete wall of varying thickness, similar to the waffle-type systems but with solid form material (foam, foam-cement composite, etc.) between the horizontal and vertical members instead of concrete. These systems have a nominal concrete thickness of 6 inches for the horizontal and vertical that creates a concrete screen instead of a concrete waffle concrete members. Maximum spacing of vertical cores and horizontal cores is defined as 12-inches on center.

Post-and-Beam ICF Wall Systems are similar to the screen-grid systems in that vertical members (columns) and horizontal members (beams) are formed. However, the spacing between them is wider, up to four feet for columns and between four and eight feet for beams.







Foam Types

ICF forms may be made from pure foams or cement composites. Pure foams can be expanded polystyrene (EPS), extruded polystyrene (XPS), polyurethane or polyisocyanurate. Most systems use EPS. XPS is available only in flat board shapes and is, therefore, not used in any block-type forms or other shaped, molded forms such as for the grid systems. Polyisocyanurate is rarely used. Cement composites may be a combination of foam and cement (always EPS) or wood and cement. Foams are rated on their thermal properties, density, strength, and resistance to wind and moisture. Foam density can have a significant impact on the physical characteristics of the foam, especially thermal insulation (R-value), strength, and moisture retention.

EPS and XPS are both made from polystyrene but the manufacturing process is different. EPS, the type of foam used for disposable coffee cups, begins as small plastic "beads" that are expanded and then fused together. XPS begins as a molten material that is pressed out of a form in a continuous process to form sheets. Polyurethanes are made from a mixture of two ingredients: an isocyanate, a polyol, and a blowing agent. Cement-foam composites are a mixture of Portland cement and EPS beads.

EPS is resistant to air infiltration, moderately strong, and usually the least expensive foam. EPS foams have R-values that range from 4.0 to 4.2 per inch when dry, based on respective densities of 1.35 to 1.8 pounds per cubic foot for Type II and Type IX foam, respectively. Type II foam, with an R-value of 4 per inch, is most commonly used in ICFs. EPS can be molded to form blocks or panels for grid or post-and-beam systems or cut into sheets for flat panel systems. It is not as resistant to moisture as XPS. Long-term exposure to moist, below-ground conditions in freezing climates will degrade foam R-value. For this reason EPS, especially, should have moisture protection when used below grade as its R-value may be reduced to 2.4 per inch under more severe conditions.

XPS foam (Type IV, V, VI, VII) has an R-value of 5 per inch when dry (4.5 per inch with long-term exposure to moist, below-ground conditions in freezing climates), regardless of density. Like EPS, XPS is resistant to air infiltration, but stronger. It is ordinarily available in sheet form only and is more expensive than EPS.

Basic Construction Steps

Below is a typical construction sequence for building walls with ICFs. For the most part, these steps apply to both above and below grade. Note that many details are not included and that exact procedures or sequence may vary according to type, manufacturer, code requirements, and/or preference. Check with the manufacturer to determine specific construction details.

Basic Construction Steps: Walls

- Place dowels (rebar) in footings, foundation wall, or slab as required.
- Place temporary or permanent braces along first course to prevent sideways movement if specified by ICF manufacturer.
- Place first course flush with braces. Blocks can be set in "green" concrete footings.
- Possibly place termite shield if required by code authority.

- Complete one course all the way around. It will likely be necessary to cut block or panel per wall segment.
- Set horizontal and vertical rebar as required.
- Subsequent courses should typically be staggered so that vertical joints do not line up from one course to the next if specified by manufacturer. Make sure vertical and horizontal cavities line up.
- Cut for openings as required (or cut out after entire wall is built)
- Install bucks/opening blockouts. A buck may be one of three types: recessed, protruding, or "channel." A pressure-treated 2x buck is frequently installed to provide an attachment surface for windows and doors. Alternatively, a water-resistant membrane may be used between wood and ICFs. Some prefabricated plastic and vinyl bucks are now available and becoming widely used. Sizing a buck is key to efficient installation of windows and doors. Whether the windows have "masonry style" window frames or frames with nailing flanges, the rough opening should be sized appropriately to accommodate the actual windows size.
- Brace forms as required. Strong, temporary bracing of all walls and openings in ICF walls is important to keep them plumb and square during the concrete pour and to support the weight of the concrete until it achieves the desired strength. Bracing is needed at corners, window, and door openings, periodically along the length of walls, and at the top of the forms. Top braces square the forms and provide a surface to check wall height and cut uneven blocks.
- Place anchor bolts and ledgers as required. Floor system attachment options include ledger, pocket, embedded joist hangers, or direct bearing. Ledgers may either be pressure treated wood or may include a water-resistant membrane. Consider where the ledger will line up with the form so it coincides with anchor bolt placement. Bolts and ledger are placed before pour, with foam cutouts around bolts to allow concrete to back up ledger (ledger face must not "bear" only on foam). Embedded joists require cutting out the foam and inserting wood spacers before the pour to create a pocket in which to seat the joist. Some code authorities also require the embedded joist to be fire-cut.
- Sleeve penetrations.
- Foam seal joints as required (possibly as you go per course). Foam sealant can be used along joints to secure blocks until concrete is poured. This is especially handy during windy conditions. Excessive sealant (gluing horizontal and vertical seams) will make it difficult to plumb the forms prior to pouring the concrete. Some ICF systems have interlocking edges to reduce or eliminate the need for gluing. Sealant, if used along the horizontal and vertical seams, will reduce cold spots at the joints where joints are not interlocking.
- Cut holes in bucks as needed to pour concrete (may be done before installation of bucks).
- Pour concrete in 2 to 4 foot lifts using chute or pump per manufacturer's instructions. A "high flow" concrete mix that will move well through a 2-inch pump is typically used. A free-flowing mix is paramount to allow concrete to flow into all interior spaces of the form. Failure to follow manufacturer's instructions for bracing and lift can result in a blow-out. If a blow-out occurs, it can then be quickly repaired. Blow-out kits are typically constructed with lumber or plywood and some form of attachment/bracing.

Additional Thoughts

ICFs have their advantages and disadvantages. Although they can be more expensive than other residential wall types, and there is much debate over their use below grade because of termites, ICFs appeal to builders and homeowners due to the many possible advantages of ICFs. Advantages over conventional construction include a reduction in the number of trade contractors required, strength, thermal efficiency, reduction in through-the-wall sound transmission, and the ease of construction.

The use of ICFs in the United States appears to be growing. The Portland Cement Association (PCA) reports that in 1994, 0.1% of all new homes used ICFs in above-grade walls (about 1100 new homes). That number rose to 1.2% in 1999, 2.7% in 2001 and increased to 3.8% in 2002.

There are currently more than 50 manufacturers of ICF systems. Many manufacturers belong to the Insulating Concrete Form Association (ICFA), an industry trade group.